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Tracking Iron Stress in Diatoms

Over emmense stretches of the equatorial Pacific Ocean, there is little marine life. Why? Because there is little to eat. Surveying these waters, biologists find low levels of phytoplankton (photosynthetic protists). Low levels of phytoplankton -- the base of the food chain -- means there is very little food for other marine organisms to eat, and as a result these areas are essentially barren "deserts" at sea. In the early to mid 1990s, a neat *in situ* experiment performed by a group of researchers under the direction of the late John Martin, a scientist at the Moss Landing Marine Laboratory in California, suggested why these ocean areas lack large stocks of phytoplankton. In Martin's experiments, fertilizing the waters with Fe (iron) led to explosive increases in phytoplankton stores: apparantly iron limitation is responsible for the low levels of photosynthetic microorganisms.

Martin's iron fertilization experiments were performed to test his controversial "iron hypothesis." Martin proposed that fertilizing these barren areas of ocean with iron could cause large phytoplankton blooms. As phytoplankton grow, they take up carbon dioxide from the atmosphere through the process of photosynthesis. Phytoplankton do not live long and after the organisms die, they sink to the ocean depths, taking the carbon with them. Martin surmised that Fe fertilization might offer a way to remedy global warming.

Global warming is the warming of the earth's atmosphere caused by the presence of increased levels of carbon dioxide in the atmosphere, trapping the sun's radiant heat and warming the earth, a consequence referred to as the "greenhouse effect." While Martin's iron fertilization experiments show that iron limitation contributes to low ocean phytoplankton levels, would increasing phytoplankton populations really be expected to have an impact on global warming?

To answer this question, we first need to get accurate estimates of the extent of ocean iron-poor zones, and develop ways to detect changes in their extent. The first step is to learn to identify waters that have low levels of iron. It is hard to measure iron levels in seawater because so many factors interact to influence its uptake by organisms. Instead, R. Michael McKay from Bowling Green State University and colleagues set out to determine if waters are low in iron by measuring "iron stress" in a natural population of phytoplankton.

The researchers chose flavodoxin as a biochemical marker of iron limitation. When a diatom (a typical phytoplankton organism) experiences iron deprivation, it replaces its ferredoxin, a key redox protein that uses Fe as an essential element, with flavodoxin, a redox protein that instead employs riboflavin 5'-phosphate. In earlier laboratory experiments, they demonstrated that the greater the iron deficiency (i.e. less Fe in the growth medium), the more flavodoxin was detected in diatom cells. The substitution of flavodoxin for ferredoxin in low iron conditions is a way the diatoms attempt to alleviate iron stress.

While initial laboratory experiments were successful, the real test of McKay's approach came next: *in situ* experiments to confirm that what happens in the test tube, happens in the ocean. His research team took to the sea to draw samples from the waters off of the coast of British Columbia. They first examined the samples to see if flavodoxin levels in diatoms were negatively correlated with iron levels in the water. They then employed their flavodoxin bioassay in Martin-style iron supplementation experiments in the laboratory. The results would indicate if flavodoxin can be utilized as an easy and accurate indicator of iron stress in diatoms, and thus of low iron conditions in ocean waters.